Earthquake Resiliency and Building Code Enforcement

Is there a connection?

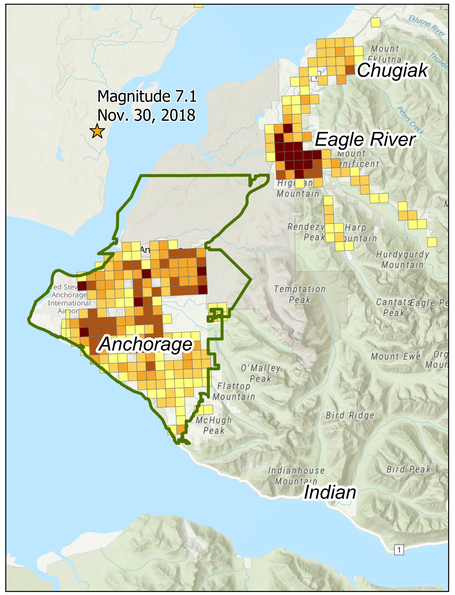
David Askov and Amanda Siok, FEMA
Ross Noffisinger and Tina Miller, Municipality of Anchorage
John Thornley, Golder Associates, Inc.

The Anchorage Building Safety Service Area (ABSSA)

Building Code Enforcement: The *"Anchorage Building Safety Service Area" (**ABSSA**)* primarily consists of the Anchorage Bowl. Building permits within the ABSSA require a plan review and a building inspection with a municipal inspector.

Outside the ABSSA: The Municipality of Anchorage does not require plan reviews and municipal inspections for construction outside of the ABSSA, including the communities of Eagle River, Chugiak, Indian, and Girdwood.

Distribution of the Damage



November 30, 2018: A magnitude 7.1 earthquake caused significant shaking in the communities of Anchorage, Eagle River, and Chugiak. The State of Alaska received thousands of requests for Individual Assistance, including residents of the Municipality of Anchorage.

- Earthquake Epicenter
- ABSSA Boundary

State of Alaska Individual Assistance Applicants per 1km Grid Cell

- 4 - 10 (<4 not shown)
- 11 - 25
- 26 - 50
- 51 - 100
- Over 100

Despite the less urban composition of Eagle River and Chugiak, their applicant densities are quite high, especially in Eagle River.

A Quick Look at the Placard Assignments

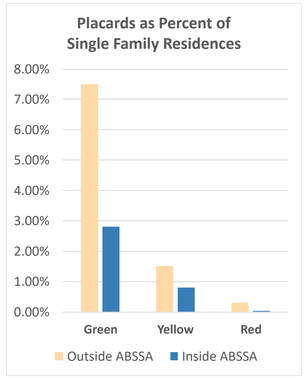
Municipality of Anchorage inspectors assigned a placard color to each inspection performed per the ATC-20 process:

- Green - Safe to inhabit, may require repairs[1]
- Yellow - Hazardous condition restricts use/occupancy
- Red - Extreme hazard, unsafe for occupancy

The table (below) and graph (right) show the placard color assignments for all single-family residences in the communities of Anchorage[2], Eagle River, and Chugiak.

TOTALS	None	Green	Yellow	Red	Inspections	Total
Inside ABSSA	43506	1272	367	8	1647	45153
Outside ABSSA	9721	804	163	34	1001	10722
PERCENTAGES	**None**	**Green**	**Yellow**	**Red**	**Inspections**	
Inside ABSSA	96.35%	2.82%	0.81%	0.02%	3.65%	
Outside ABSSA	90.66%	7.50%	1.52%	0.32%	9.34%	
Ratio out/in:	**0.94**	**2.66**	**1.87**	**17.90**	**2.56**	

The bottom row shows the ratio of the rates outside the ABSSA to the rates inside. At all 3 placard colors, the areas outside the ABSSA sustained much higher rates of damage.



[1] Green generally indicates damage sustained requiring repair. This level of damage however did not warrant a yellow or red placard.
[2] 99.1% of Anchorage's single family residences fall inside the ABSSA.

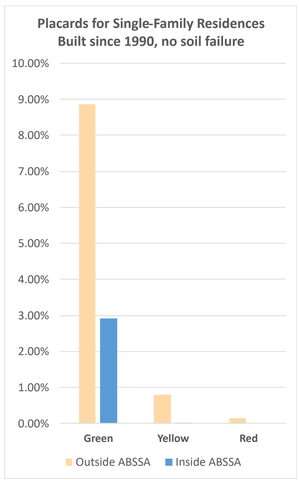
Building Code Enforcement

By 1990 modern seismic provisions were being enforced within the ABSSA on single family home construction. For that reason, these results show only single family residences built since 1990.

Some of the earthquake damage was caused by soil failure under these houses. Because the building codes and inspections would not have predicted that, those inspections were also removed from this analysis.

TOTALS	None	Green	Yellow	Red	Inspections	Total
Inside ABSSA*	10772	324	1	0	325	11097
Outside ABSSA	3755	369	33	6	408	4163
Eagle River	2720	326	30	4	360	3080
Chugiak	836	38	3	1	42	878
Anchorage*	199	5	0	1	6	205
PERCENTAGES	**None**	**Green**	**Yellow**	**Red**	**Inspections**	
Inside ABSSA*	97.07%	2.92%	0.01%	0.00%	2.93%	
Outside ABSSA	90.20%	8.86%	0.79%	0.14%	9.80%	
Eagle River	88.31%	10.58%	0.97%	0.13%	11.69%	
Chugiak	95.22%	4.33%	0.34%	0.11%	4.78%	
Anchorage*	97.07%	2.44%	0.00%	0.49%	2.93%	
Ratio out/in:	**0.93**	**3.04**	**87.97**	**---**	**3.35**	

* In the community boundary of Anchorage, this analysis includes 11,097 residences *inside* the ABSSA and 205 *outside*.

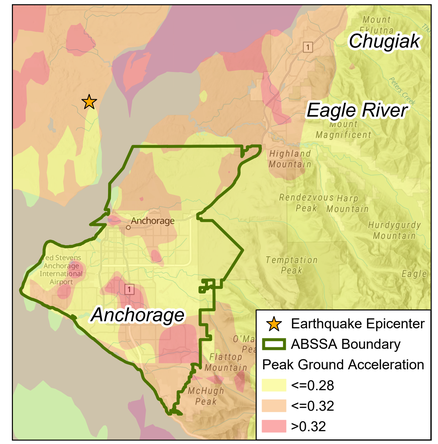


Analyzing only homes built since 1990 and not experiencing soil failure, both inside and outside the ABSSA show decreased rates of damage. That said, the inspections **inside the ABSSA experienced much lower rates of damage**, with only one yellow placard and **no red placards**.

Breakdown by Levels of Shaking

Peak ground acceleration (PGA) measures the intensity of the ground motion experienced during the earthquake, with higher values indicating more intense ground motion. The International Building Code requires buildings in Anchorage to resist a minimum PGA level of 0.5g. Only isolated locations in the Municipality reached that level of ground motion, with most residences experiencing only 60% or less of that.

This map originated from the USGS ShakeMap PGA and was augmented with a map from Golder Associates interpolating sensor data available in the most populated parts of Anchorage.



ShakeMap PGA ≤0.28										
	None	Green	Yellow	Red	Inspections	None	Green	Yellow	Red
Inside ABSSA	5849	191	0	0	191	96.84%	3.16%	0.00%	0.00%
Outside ABSSA	1000	104	7	0	111	90.01%	9.36%	0.63%	0.00%
Anchorage	58	2	0	0	2	96.67%	3.33%	0.00%	0.00%
Chugiak	105	9	0	0	9	92.11%	7.89%	0.00%	0.00%
Eagle River	837	93	7	0	100	89.33%	9.93%	0.75%	0.00%
					Ratio out/in:	**0.93**	**2.96**	**---**	**---**

ShakeMap PGA ≤0.32									
	None	Green	Yellow	Red	Inspections	None	Green	Yellow	Red
Inside ABSSA	3554	100	1	0	101	97.24%	2.74%	0.03%	0.00%
Outside ABSSA	2226	206	23	5	234	90.49%	8.37%	0.93%	0.20%
Anchorage	123	3	0	1	4	96.85%	2.36%	0.00%	0.79%
Chugiak	731	29	3	1	33	95.68%	3.80%	0.39%	0.13%
Eagle River	1372	174	20	3	197	87.44%	11.09%	1.27%	0.19%
					Ratio out/in:	**0.93**	**3.06**	**34.17**	**---**

ShakeMap PGA >0.32									
	None	Green	Yellow	Red	Inspections	None	Green	Yellow	Red
Inside ABSSA	1369	33	0	0	33	97.65%	2.35%	0.00%	0.00%
Outside ABSSA	529	59	3	1	63	89.36%	9.97%	0.51%	0.17%
Anchorage	18	0	0	0	0	100.00%	0.00%	0.00%	0.00%
Chugiak	0	0	0	0	0	---	---	---	---
Eagle River	511	59	3	1	63	89.02%	10.28%	0.52%	0.17%
					Ratio out/in:	**0.92**	**4.23**	**---**	**---**

These tables show rates of damage at different levels of ground motion. Variations in the intensity of ground motion do not appear to be a significant factor in explaining the higher rate of damage experienced outside the ABSSA.

Future Directions

PGA Maps: Outside the most populated parts of Anchorage, there are fewer sensors used to create the USGS ShakeMap. Improving the detail of the ShakeMap will enable a better understanding of the effects of ground motion on residential damage.
Future Earthquakes: Because this earthquake's ground motion (PGA) only reached the building code's minimum level in a few isolated pockets, repeating this analysis in future events will add greater understanding.
Additional Factors: Analyze if other factors (e.g.: socioeconomic data, appraisal value, English proficiency, building on historical marshlands) affect the rates of damage reported.

Base Map Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
ATC-20: https://www.atcouncil.org/atc-20
USGS ShakeMap: https://earthquake.usgs.gov/data/shakemap/
Golder Associates, Inc.: https://www.golder.com/